U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-271 658

Blue Mesa Reservoir
Gunnison County, Colorado

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Jul 77

PB 271 658

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE

REPORT

ON

BLUE MESA RESERVOIR

GUNNISON COUNTY

COLORADO

EPA REGION VIII

WORKING PAPER NO. 267

WITH THE COOPERATION OF THE

COLORADO DEPARTMENT OF HEALTH

AND THE

COLORADO NATIONAL GUARD

JULY, 1977

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Blue Mesa Reservoir, Gunnison County, Colorado	5. REPORT DATE Prepared July 1977
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)	8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 767
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460	13. TYPE OF REPORT AND PERIOD COVERED Final - 1975 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS	17b. IDENTIFIERS/OPEN ENDED TERMS	17c. COSATI Field/Group
Eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS (This Report) 20. SECURITY CLASS (This page)	21. NO. OF PAGES 62 22. PRICE

EPA Form 2220-1 (9-73)

CONTENTS

	Page
Foreward	ii
List of Colorado Study Lakes and Reservoirs	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	9
V. Literature Reviewed	14
VI. Appendices	15

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning (§303(e)), water quality criteria/standards review (§303(c)), clean lakes (§314(a,b)), and water quality monitoring (§106 and §305(b)) activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Colorado Department of Health for professional involvement, to the Colorado National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Control Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Lt. Colonel Paul A. Parsons, the Deputy Adjutant General of Colorado, and Project Officer Colonel Hershel C. Yeargan, who directed the volunteer efforts of the Colorado National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS

STATE OF COLORADO

NAME	COUNTY
Barker	Boulder
Barr	Adams
Blue Mesa	Boulder
Cherry Creek	Arapahoe
Cucharas	Huerfano
Dillon	Summit
Grand	Grand
Green Mountain	Summit
Holbrook	Otero
Meredith	Crowley
Milton	Weld
Navajo	Archuleta, CO; San Juan, Rio Arriba, NM
Shadow Mountain	Grand

BLUE MESA RESERVOIR

BLUE MESA RESERVOIR

STORET NO 0803

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Blue Mesa Reservoir is mesoeutrophic. It ranked sixth in overall trophic quality when the 13 Colorado lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. Three of the waterbodies had less median total phosphorus, four had less median dissolved orthophosphorus, none had less and six had the same median inorganic nitrogen, seven had less mean chlorophyll a, and three had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at sampling stations 4 and 5 in August and at stations 3 and 4 in September; and it is reported that some of the embayments become anaerobic in the summer (Wiltzius, 1977).

Survey limnologists observed clumps of algae at the surface near station 6 in September.

B. Rate-Limiting Nutrient:

Due to significant changes in nutrients in the samples during shipment from the field to the laboratory, the algal assay results are not considered representative of conditions in the reservoir at the times the samples were collected (08/26/75 and 09/29/75).

The reservoir data indicate nitrogen limitation at all sampling stations and times.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--The phosphorus contributions of known point sources accounted for 3.2% of the total load to Blue Mesa Reservoir during the sampling year. The City of Gunnison added 2.6% of the total load; the Tall Texan Trailer Court, 0.3%; Lake City, 0.1%; and septic tanks serving shoreline dwellings and recreational areas were estimated to have contributed less than 0.1%.

The present phosphorus loading of 2.66 $g/m^2/yr$ is more than twice that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). It is calculated that even complete removal of point-source phosphorus would still leave a loading in excess of a eutrophic loading. However, the point-source assessment is based on only five Gunnison effluent samples (Appendix E) and estimated loads for the other point sources, so the actual point-source contributions may be greater than indicated (e.g., note that the apparent phosphorus contribution of the City of Gunnison was only 0.5 kg/capita/year).

A need for a more-detailed study of point-source contributions is indicated.

2. Non-point sources--It is estimated that non-point sources including direct precipitation, contributed 96.8% of the total phosphorus load to the reservoir during the sampling year.

The Gunnison River added 53.0% of the total; the Lake Fork Gunnison River, 14.4%; Cebolla Creek, 7.5%; Willow Creek, 8.2%; Soap Creek, 4.5%; and the ungaged minor tributaries and immediate drainage contributed an estimated 8.5%.

The phosphorus export rates of Soap and Willow creeks were substantially higher than the rates of the other reservoir tributaries (see page i2). The higher rates may have been the result of insufficient sampling; i.e., only six Soap Creek samples and three Willow Creek samples were collected (Appendix E).

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 36.62 kilometers².
2. Mean depth: 31.1 meters.
3. Maximum depth: 104.2 meters.
4. Volume: 1,138.082 x 10^6 m^3.
5. Mean hydraulic retention time: 320-330 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Gunnison River	5,524.5	24.780
Lake Fk. Gunnison River	955.7	7.430
Cebolla Creek	955.7	3.130
Willow Creek	186.5	0.007
Soap Creek	181.3	1.960
Minor tributaries & immediate drainage -	1,033.0	10.350
Totals	8,836.7	47.647

2. Outlet -

Gunnison River	8,873.3**	47.647**

C. Precipitation***:

1. Year of sampling: 23.6 centimeters
2. Mean annual: 28.6 centimeters.

† Table of metric conversions--Appendix B.
†† Anderson, 1974; retention time, mean depth, and maximum depth - Wilstus, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Blue Mesa Reservoir was sampled two times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at six stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during both visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 57.9 meters at station 1, 53.3 meters at station 2, 47.2 meters at station 3, 31.7 meters at station 4, 25.3 meters at station 5, and 12.5 meters at station 6.

The sampling results are presented in full in Appendix D and are summarized in the following table.

[illegible] SUMMARY OF [illegible] AND [illegible] CHARACTERISTICS OF [illegible]
[illegible] LAKE [illegible]

[illegible]	1ST SAMPLING ([illegible])			3RD SAMPLING ([illegible])			4TH SAMPLING ([illegible]
	[illegible]			[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TEMP (C)	6.2 - 15.5	15.-	14.9	6.7 - 16.7	14.7	15.0	[illegible]
[illegible]	1.4 - 7.2	5.2	6.5	1.2 - 6.6	5.4	7.0	[illegible]
[illegible]	92. - 107.	152.	154.	84. - 111.	131.	147.	[illegible]
[illegible]	7.3 - 8.5	8.2	8.3	7.6 - 8.4	8.3	8.4	[illegible]
[illegible]	4.- - 13.-	9.	8.	5.- - 11.-	9.-	10.	[illegible]
[illegible]	0.012 - 0.352	0.038	0.039	0.013 - 0.044	0.029	0.035	[illegible]
[illegible]	0.002 - 0.039	0.011	0.014	0.002 - 0.037	0.015	0.015	[illegible]
[illegible]	0.011 - 0.231	0.04-	0.029	0.015 - 0.240	0.013	0.025	[illegible]
[illegible]	0.025 - 0.079	0.028	0.029	0.028 - 0.071	0.032	0.025	[illegible]
[illegible]	0.200 - 0.480	0.237	0.251	0.200 - 0.445	0.251	0.288	[illegible]
[illegible]	0.240 - 0.750	0.34-	0.340	0.240 - 0.36-	0.245	0.240	[illegible]
[illegible]	0.232 - 0.429	0.29-	0.328	0.239 - 0.448	0.29-	0.278	[illegible]
[illegible]	4.2 - 6.7	4.-	4.8	5.2 - 17.6	6.7	5.2	[illegible]
[illegible]	1.3 - 2.5	2.-	2.1	2.- - 3.1	2.3	3.-	[illegible]

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
08/26/75	1. Aphanizomenon sp.	1,324
	2. Chroomonas sp.	461
	3. Cryptomonas sp.	230
	4. Fragilaria sp.	115
	5. Microcystis sp.	115
	Other genera	231
	Total	2,476
09/29/75	1. Aphanizomenon sp.	4,391
	2. Chroomonas (?) sp.	187
	3. Fragilaria sp.	93
	4. Cryptomonas sp.	93
	5. Schroederia sp.	47
	Total	4,811

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
08/26/75	1	6.0
	2	4.1
	3	4.6
	4	4.2
	5	5.2
	6	5.4
09/29/75	1	7.1
	2	7.2
	3	6.6
	4	5.1
	5	8.5
	6	17.3

C. Limiting Nutrient Study:

Due to significant changes in nutrients in the samples from the time of collection to the beginning of the assays, the results of the algal assays are not considered representative of conditions in the reservoir at the times the samples were taken (08/26/75 and 09/29/75).

The reservoir data indicate nitrogen limitation at all sampling stations and times. The mean inorganic nitrogen to orthophosphorus ratios were 10 to 1 or less, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Colorado National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the months of June and August when two samples were collected at most of the sites. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Colorado District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in kg/km^2/year, at station C-1 and multiplying by the ZZ area in km^2.

The operator of the Gunnison wastewater treatment plant provided monthly effluent samples and corresponding flow data. The operator of the Tall Texan Trailer Court plant could not provide flows, and Lake City did not not participate; nutrient loads from these sources were estimated at 1.134 P and 3.401 N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Gunnison*	5,000	tr. filter	3972.4	Gunnison River
Tall Texan Tr. Ct.*	250	act. sludge	94.6	Gunnison River
Lake City**	110	ext. aer.	41.6	Lake Fk. Gunnison R.

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Gunnison River	51,690	53.0
Lake Fk. Gunnison River	14,000	14.4
Cebolla Creek	7,345	7.5
Willow Creek	8,015	8.2
Soap Creek	4,435	4.5
b. Minor tributaries & immediate drainage (non-point load) -	8,265	8.5
c. Known municipal STP's -		
Gunnison	2,750	2.8
Tall Texan Tr. Ct.	285	0.3
Lake City	125	0.1
d. Septic tanks† -	10	< 0.1
e. Known industrial - None	-	-
f. Direct precipitation†† -	640	0.7
Total	97,560	100.0

2. Outputs -

Reservoir outlet - Gunnison River 30,730

3. Net annual P accumulation - 66,830 kg.

* Hinman, 1974.
** Anonymous, 1971.
† Estimate based on 20 shoreline dwellings and two campgrounds; see Working Paper No. 175.
†† See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Gunnison River	789,985	65.9
Lake Fk. Gunnison River	163,930	13.7
Cebolla Creek	46,745	3.9
Willow Creek	70,835	5.9
Soap Creek	26,175	2.2
b. Minor tributaries & immediate drainage (non-point load) -	50,615	4.2
c. Known municipal STP's -		
Gunnison	10,430	0.9
Tall Texan Tr. Ct.	850	< 0.1
Lake City	375	< 0.1
d. Septic tanks* -	355	< 0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	39,535	3.3
Total	1,199,830	100.0

2. Outputs -

Reservoir outlet - Gunnison River	817,720

3. Net annual N accumulation - 382,110 kg.

* Estimate based on 20 shoreline dwellings and two campgrounds; see Working Paper No. 175.
** See Working Paper No. 175.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Gunnison River	9	141
Lake Fk. Gunnison River	15	172
Cebolla Creek	8	49
Willow Creek	43	310
Soap Creek	24	144

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Cebolla Creek (C-2)	0.115	0.907
Steuben Creek	0.067	0.893
East Elk Creek	0.107	0.736
Red Creek	0.130	1.006

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	2.66	1.62	32.8	10.4

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Blue Mesa Reservoir:

"Dangerous" (eutrophic loading)	1.14
"Permissible" (oligotrophic loading)	0.57

V. LITERATURE REVIEWED

Anderson, R. Dennis, 1974. Personal communication (waterbody information and morphometry). CO Dept. of Health, Denver.

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 8, Wash., DC.

Hinman, H. Fred, 1974. Treatment plant questionnaires. Montrose, CO.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Wiltzius, William J., 1977. Personal communication (review of preliminary report). CO Divn. of Wildlife, Montrose.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] TOTAL N	[illegible]	[illegible] CHLPA	[illegible]	[illegible] SECCHI DEPTH
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

LAKE CODE	LAKE NAME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
1	[redacted]	[redacted]	[redacted]
2	[redacted]	[redacted]	[redacted]
3	[redacted]	[redacted]	[redacted]
4	[redacted]	[redacted]	[redacted]
5	[redacted]	[redacted]	[redacted]
6	[redacted]	[redacted]	[redacted]
7	[redacted]	[redacted]	[redacted]
8	[redacted]	[redacted]	[redacted]
9	[redacted]	[redacted]	[redacted]
10	[redacted]	[redacted]	[redacted]
11	[redacted]	[redacted]	[redacted]
12	[redacted]	[redacted]	[redacted]
13	[redacted]	[redacted]	[redacted]

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[redacted]

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

APPENDIX I

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							

[illegible]

[redacted]

[redacted]

[redacted]							
[redacted]							
[redacted]							
[redacted]							
[redacted]							
[redacted]							
[redacted]							
[redacted]							

[redacted]

[illegible]

[illegible]

[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	18	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	18	75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	17	72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]									
[illegible]									
[illegible]									
[illegible]									

[illegible]

[illegible]

[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]